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# A DEMOUNTABLE ALL METAL HOT-CATHODE VACUUM IONISATION GAUGE*

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**ABSTRACT** An all metal demountable hot-cathode vacuum ion-gauge has been constructed whose filament can be changed any number of times without a change in the operational characteristics. The characteristic curves of the gauge have been given. Some points towards the constructional improvements have been discussed which might account for better sensitiveness.

A hot-cathode demountable type sturdy metal ion-gauge has been developed, the filament of which can be changed within a short time any number of times after it is poisoned or burnt out, without a change in the characteristics of the gauge operation. This gauge has been constructed out of the materials readily available in the laboratory store. Though not so sensitive like the modern glass envelope types, it is suitable particularly for a dynamic metal vacuum system. It is well known that the greatest disadvantage for a hot-cathode ion-gauge is the life of the cathode. The cathode is likely to be poisoned, if not destroyed by gases like oxygen and hydro-carbon vapours, etc., (Dushman, 1949) which are very difficult to get rid of in a vacuum system ; many vacuum operations necessitate the introduction of air from time to time, each time the ion-gauge has to be re-exhausted and the gases absorbed by the electrodes while in presence of air have to be removed, which is usually done by increasing the electron emission from the cathode more than the normal rating for a little time. This also causes shortening of the cathode life.

The average life of each filament used in this gauge is of the order of that of the tungsten filament of the commercial type ion-gauges with glass envelopes, e. g. R. C. A. 1950. So, economically it has one advantage over the commercial type, whose filament, if once loses its emissive properties has to be rejected permanently.

Attempts have been made to incorporate the desirable features found in the previous designs (Buckley, 1916 ; Dushman and Found, 1921 : Morse & Bowie, 1940), e. g. reliability, high insulation for the ion-collector, long filament life etc.

The gauge envelope has been represented pictorially in figure 1 and figure 2 shows the photograph to the filament and the grid-structure.

* Communicated by Prof. B. D. Nag.

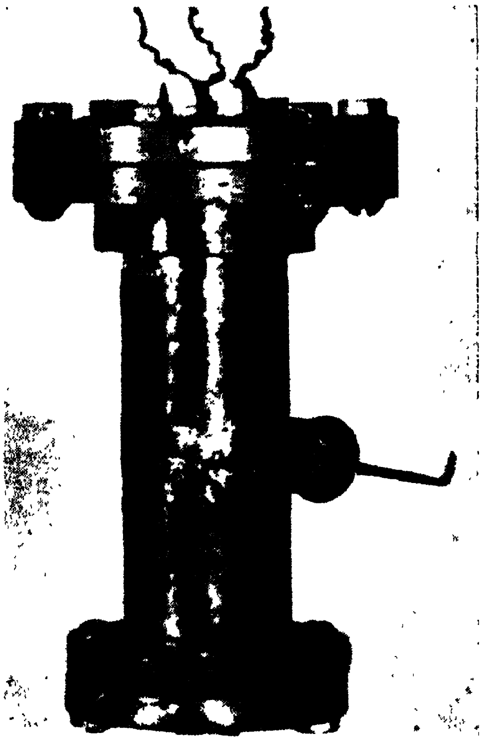


Fig. 1

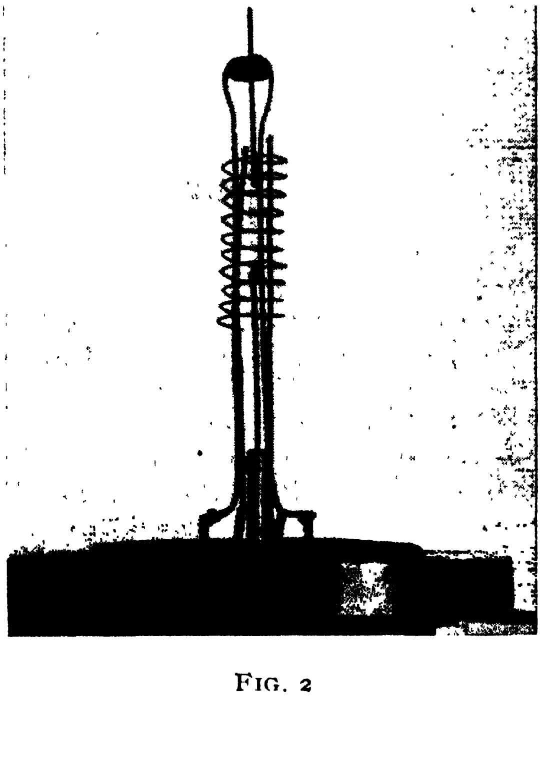


Fig. 2

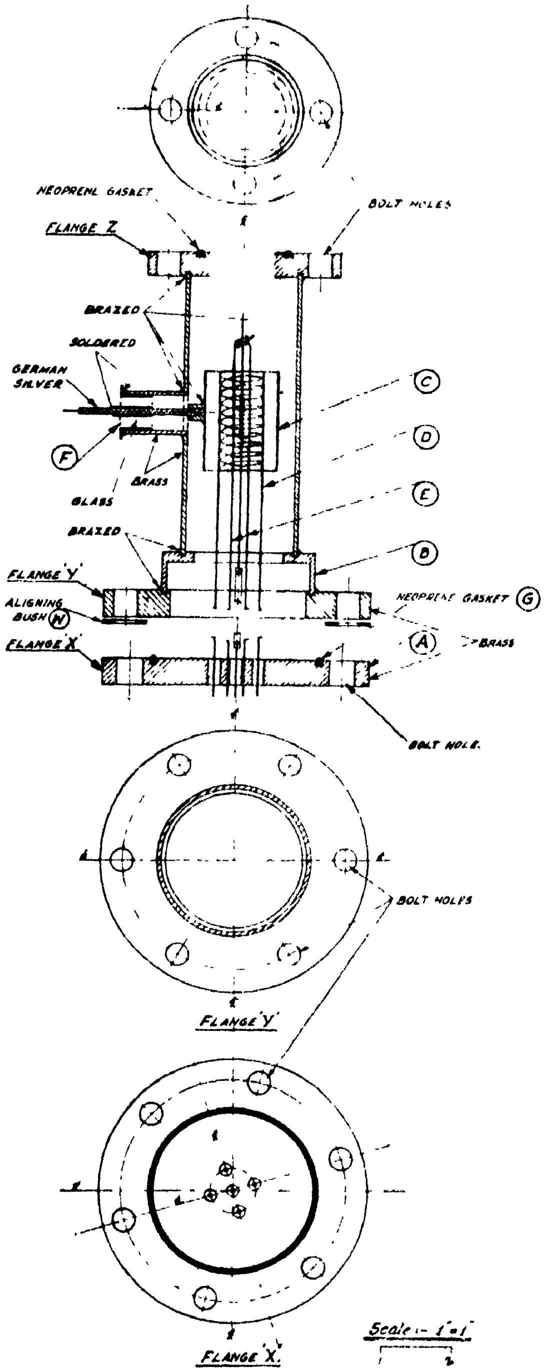

NEOPRENE GASKET
BOLT HOLES
FLANGE Z
BRAZED
SOLDERED
GERMAN SILVER
F
BRASS
GLASS
BRAZED
C
D
E
B
FLANGE 'Y'
ALIGNING BUSH H
NEOPRENE GASKET G
FLANGE 'X'
A
BRASS
BOLT HOLE
BOLT HOLES
FLANGE 'Y'
FLANGE 'X'

FIG. 3

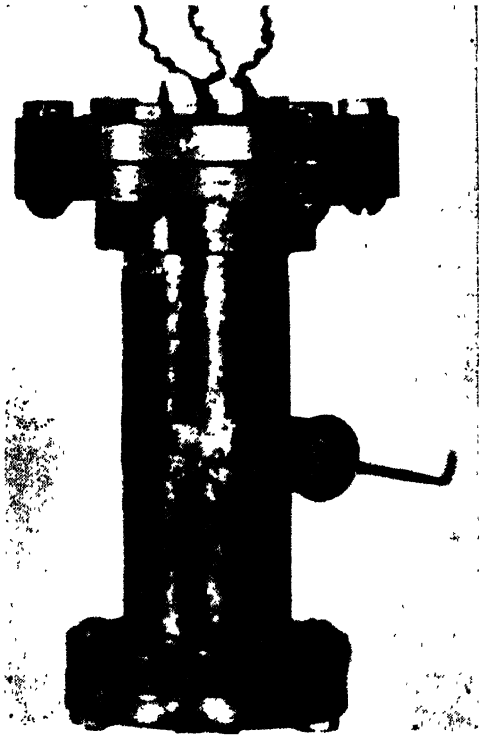


FIG. 1

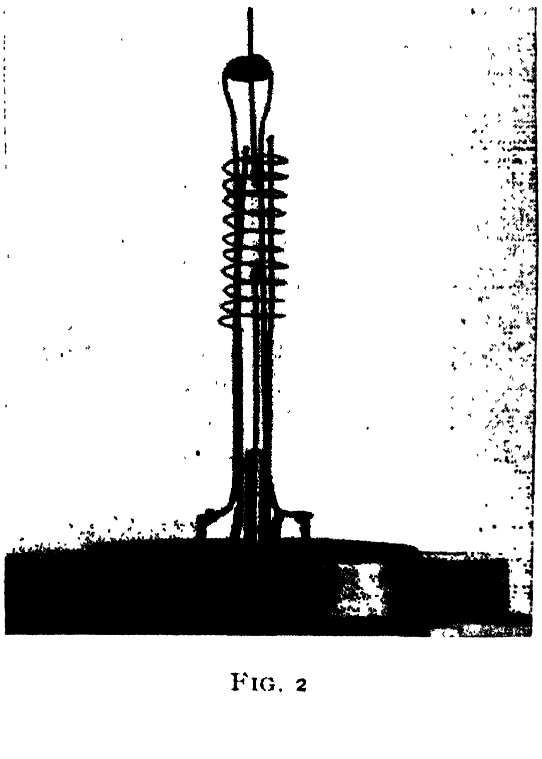
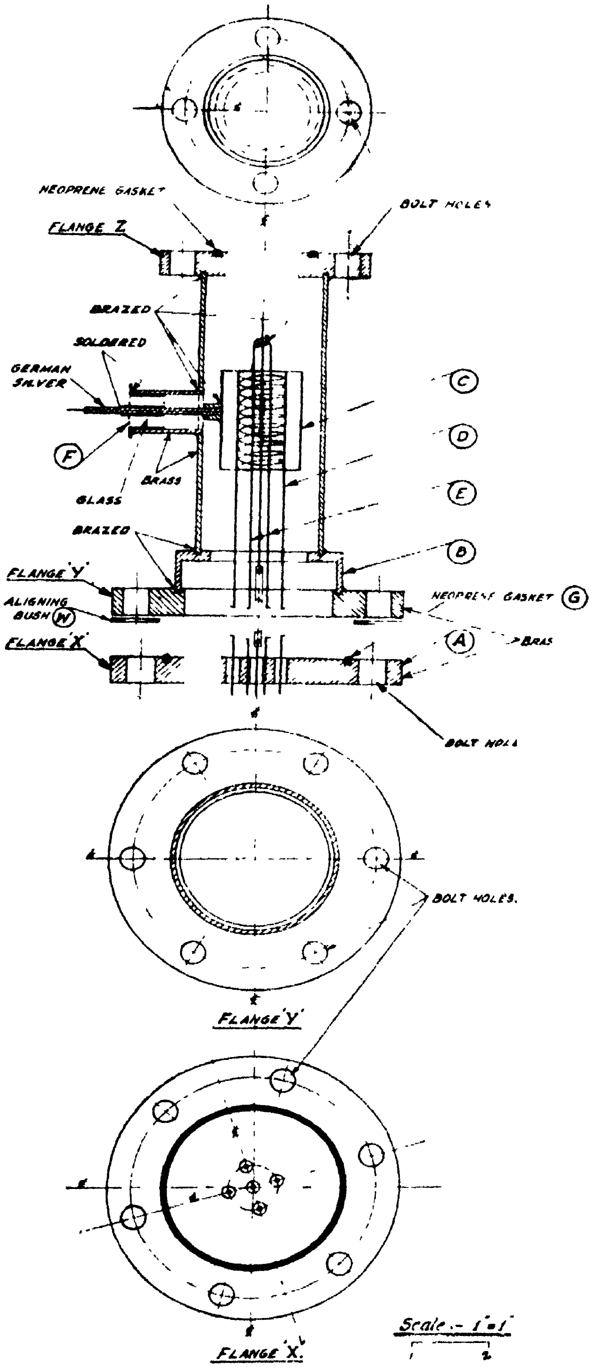


FIG. 2



NEOPRENE GASKET
FLANGE Z
BOLT HOLES
BRAZED
SOLDERED
GERMAN SILVER
C
D
E
F
BRASS
GLASS
BRAZED
B
FLANGE 'Y'
ALIGNING BUSH W
NEOPRENE GASKET G
FLANGE 'X'
A
BOLT HOLE
BOLT HOLES.
FLANGE 'Y'
FLANGE 'X'
Scale :- 1"=1"


FIG. 3

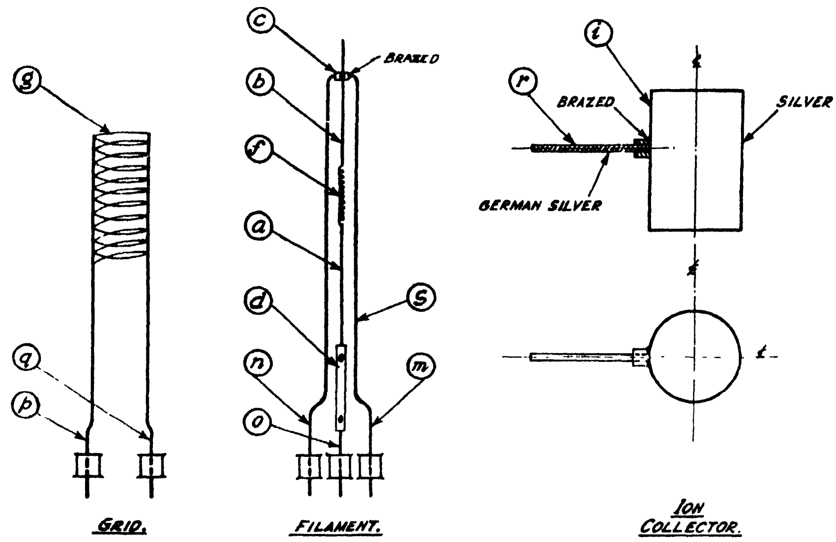

BRAZED
BRAZED
SILVER
GERMAN SILVER
GRID.
FILAMENT.
ION COLLECTOR.

FIG. 4

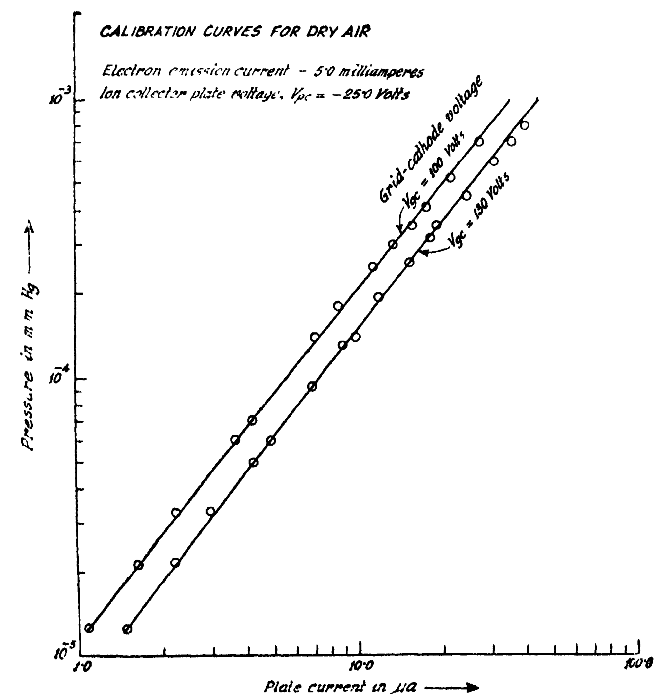

CALIBRATION CURVES FOR DRY AIR
Electron emission current - 5·0 milliamperes
Ion collector plate voltage, Vpc = -25·0 Volts
Grid-cathode voltage
Vgc = 100 Volts
Vgc = 130 Volts
Pressure in mm Hg
Plate current in μa
1·0
10·0
100·0

FIG. 5

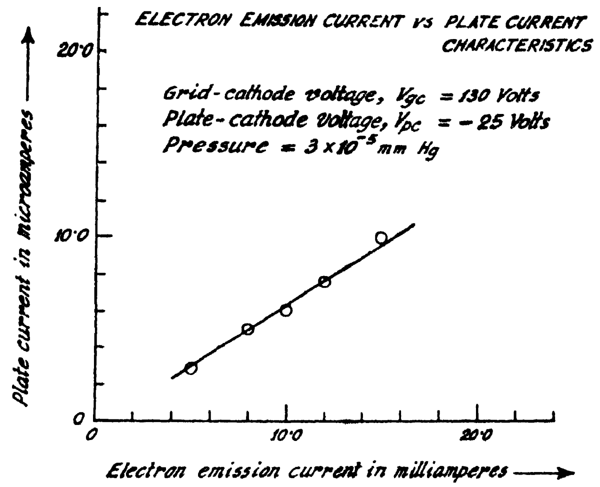



Fig. 6

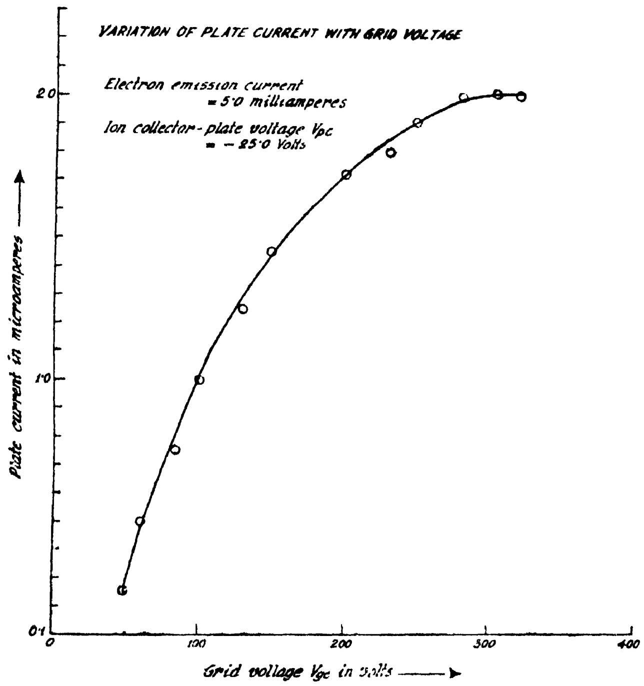



Fig. 7

The construction of the gauge can be understood from figure 3. The gauge body is made of brass. The portions *A* and *B* which are originally attached to each other when in operation with the Neoprene gasket *G* and nut bolts through the flanges *X* and *Y* can be separated whenever it is required to change the filament. Alignment between them during each assembly, is done by an 'index' mark and the aligning bush $W$. The gauge is connected to the vacuum system with the flange $Z$. The structures of the plate $C$, grid $D$ and the filament $E$ have been shown separately in figure 4.

The filament $f$ is a 6 mil. tungsten wire, 2 inch in length, coiled on a 50 mil. mandrel, the coil length being about 3/4th inch. The two ends of the filament are spot-welded (via nickel medium) with two short tungsten wires $a$, $b$ of 40 mil. diameter which are inserted into two small brass-holders $c$, $d$ and held by set screws. The upper holder $c$ is brazed to the 40 mil. tungsten wire support $s$ of the filament structure and the lower one $d$ is clamped to the terminal of the Kovar-glass seal $o$, soldered to the metal flange $X$. For a change of the filament the unit $a\ b\ f$ can be taken out as a whole by loosening the screws on $c\ d$ and a new unit can be put in. For normal operation, as shown in the calibration curve (figure 5), the filament requires about 3.0 amps. of current at 6.5 volts.

The grid $g$ is a 10 turn spiral of 15 mil. molybdenum wire (wound on a ½ inch. cylindrical mandrel). Each turn of the spiral being spot-welded to the two supporting 40 mil. nickel wires. The nickel wires were again spot-welded to the Kovar-glass seal terminals $p$ and $q$ on the metal flange $X$. The coil length of the grid spiral was 1⅜ inch and the relative distance between each turn of the spiral was ⅛ inch.

The ion collector $i$, was a hollow silver cylinder 6 mil. thick, 1½ inch. in length, its inside diameter being 1 inch. It was supported by a German silver wire $r$ 60 mil. thick lead in through the Kovar-glass seal $F$, as shown in figure 3, soldered to the gauge metal wall.

In the present design outgassing of the electrodes was difficult, and required longer time than that required for the commercial types of gauges, e.g., RCA 1950, complete outgassing being hardly possible. The only means of degassing the plate and grid structures in this present gauge is by electron bombardment. Moreover, the inner wall of the metal gauge-body was a constant source of gassing. So another metal demountable type of gauge with a glass envelope round the inner wall of the gauge body to minimize the metal surface exposed to the operation as far as possible, has been designed. It has a thin ion collecting electrode made of nickel, and the grid structure is helical ; provision has been made to heat the grid to sufficient temperature for better outgassing by passing current through it.

With "External Control" type circuit arrangement the observed characteristic curves have been given in figures 5, 6, and 7.

For comparison, the characteristics of a commercial type ion-gauge with glass envelope, RCA 1950 are given along with it, in figure 8, taken from the R C A Tube Manual—9205—6818.

Kelly (1950) has described an all metal ion-gauge, on which he has used water coils for cooling the gauge body. In this present gauge no such cooling device has been used, as it was thought that it would make it complicated and inconvenient to use. The gauge, though worked at a temperature 2 to 3°C higher than the room temperature due to the heat dissipated from the filament and the other electrodes, gave consistent readings

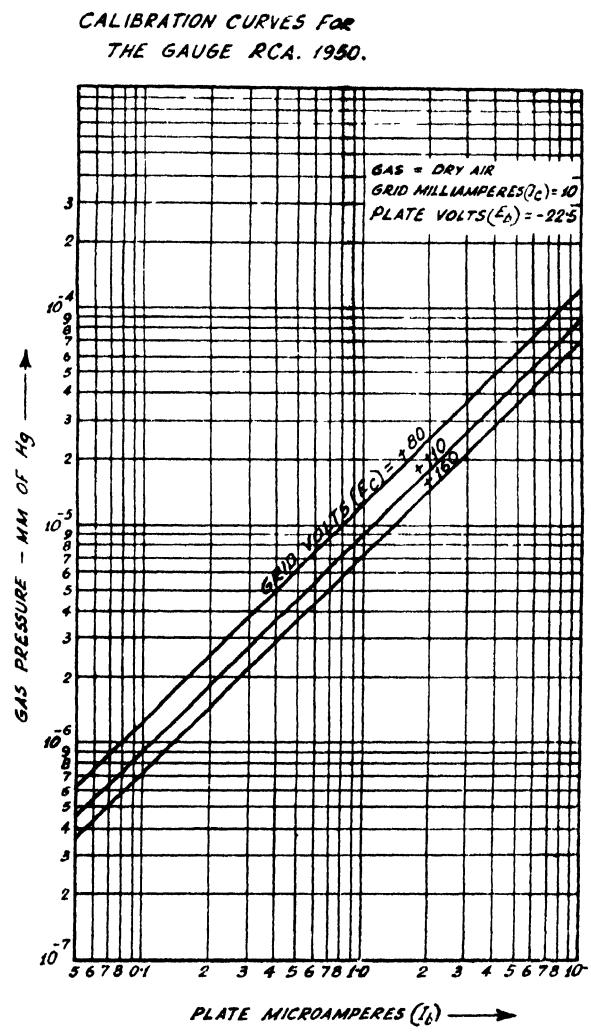



FIG. 8

when compared and calibrated against the gauge RCA 1950, on different occasions under different conditions for a pressure range of $1 \times 10^{-3}$ mm. to $8 \times 10^{-6}$ mm. Hg.

It can conveniently be used for hunting leaks without any great care for the safety of the filament, as it can be replaced readily and easily without dismantling the gauge envelope. The gauge has been tested on the vacuum system of the 38 inch cyclotron of the Institute of Nuclear Physics, Calcutta University. It has the added advantage that it has practically no r.f. pick up from the cyclotron oscillator without any extra shielding arrangement.

ACKNOWLEDGMENTS

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Kelly, F, M. 1950, *Rev Sci. Instr* , **21**, 675.

Morse, R. S and Bowie R. M. 1940, *Rev. Sci. Instr.*, **11**, 91.